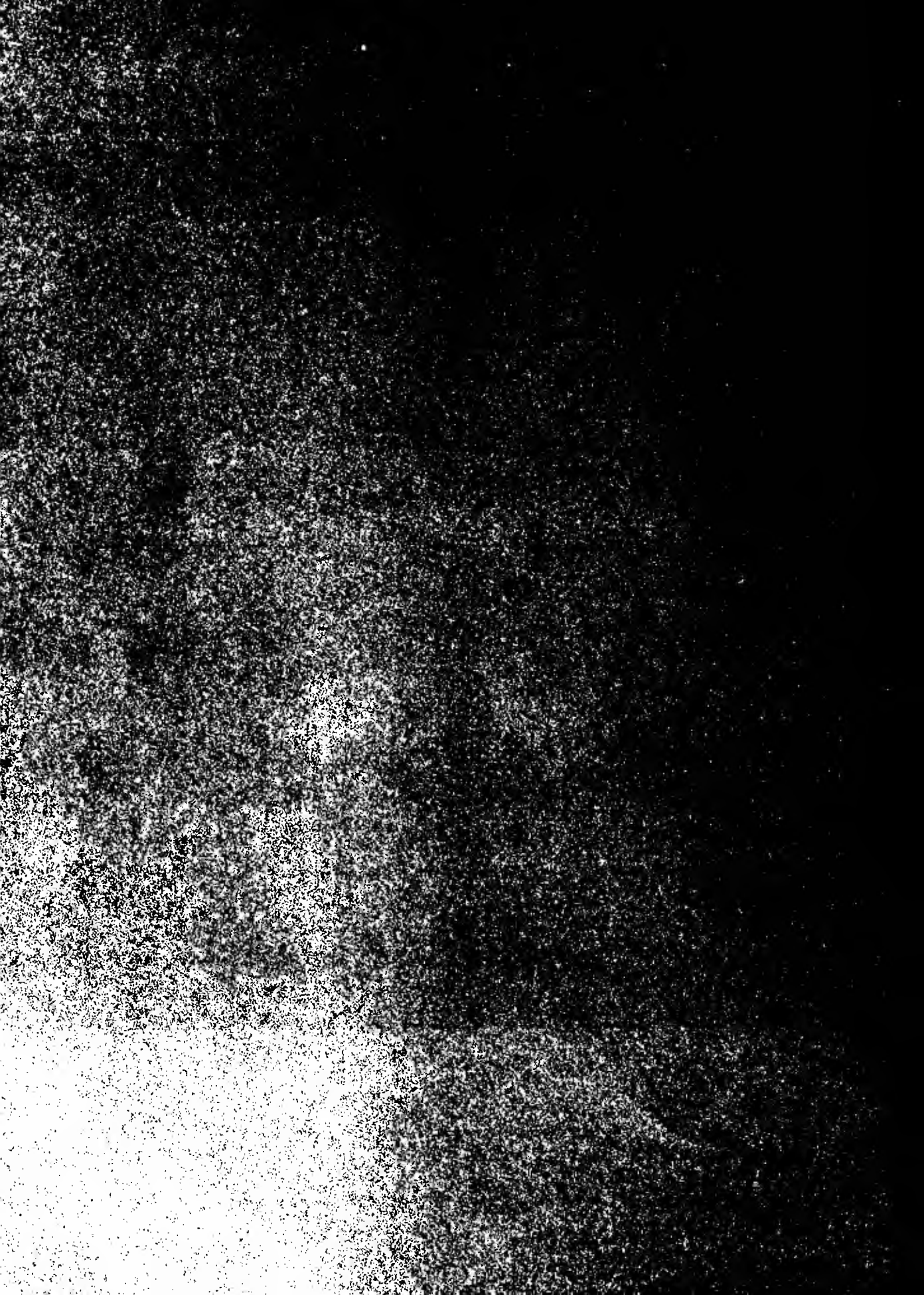

# THE PROCESS OF PROBLEM FINDING

148-65



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# THE PROCESS OF PROBLEM FINDING

## Introduction

As a result of research efforts over the past twenty years, a number of extremely effective analytical techniques are currently available for the solution of management problems. Linear programming is used routinely in the specification of optimum cattle feeds and fertilizers. Decision rules based on inventory models form the basis for production and inventory control systems in wide variety of manufacturing companies. Simulation is evolving from a means for doing research on complex managerial problems to a process which can provide useful information to managers on a real-time basis.

Like other technological changes, these methods raise a number of social and organizational issues within the organizations which use them, but their net contribution is no longer seriously in doubt. As a result, in most large organizations and in many smaller ones, operating managers either are themselves aware of these methods or have ready access to help and advice in their application if it is required.

But the manager's job is not only to solve well-defined problems. He must somehow identify the problems to be solved. He must somehow assess the cost of analysis and its potential return. He must allocate resources to questions before he knows their answers. To many managers

designed by individuals who, through years of experience, had learned ways to get these jobs done. With few exceptions these individuals could not be explicit about how they performed these tasks and, as a result, training for these jobs was a slow process and the development and testing of new procedures was difficult indeed.

So it is with the process of problem finding today. All managers have discovered ways to maintain a list of problems which can occupy their working hours -- and other hours as well. They frequently find it difficult, however, to be explicit about the process by which their problems are selected -- and, as a result, training for managerial positions is slow and the development and testing of new and possibly better problem finding procedures is difficult.

Since 1945, however, some progress has been made in understanding certain cognitive tasks in the areas of production and inventory control. Decisions rules have been derived from mathematical models of particular tasks and in a number of cases these rules have performed as well or better than the complex intuitive process they have replaced. The significant fact about these developments for this discussion is, not the economic impact of such rules (although it has been significant), but rather the implication that the essential processes by which important decisions are made may be carried out satisfactorily by simple explicit decision rules which are easy to teach and execute and easy to improve through analysis, simulation or experimentation.

Of course it is possible to discount these accomplishments by saying that inventory decisions were always rather simple ones to make. The validity of such arguments, however, seems suspiciously dependent on knowledge of what has been accomplished and on a lack of knowledge of inventory systems.

It is true, however, that mathematical analysis has not been able to suggest decision rules for a wide variety of managerial tasks. Jobs like product design, personnel selection, and others including the definition of problems seem to require symbols and analytical procedures not readily represented by standard mathematical forms. Some other means for discovering the (hopefully simple, explicit) decision rules by which such tasks are performed is clearly required.

Some progress in this direction has already been made. Encouraged both by the success of the analytical approach to decision problems, and by the availability of large digital computers, Newell, Simon and others have been studying human decision behavior since the early 1950's. They have focussed their attention primarily on tasks which would facilitate the development of a methodology for approaching decision situations not readily describable in mathematical terms. They have considered the decision processes involved in proving theorems in symbolic logic[1/] and

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[1/] Newell, A., J. C. Shaw, and H. A. Simon, "Empirical Explorations of the Logic Theory Machine," Proceedings of the Western Joint Computer Conference (February, 1957), pp. 218-230.

plane geometry.[2] They have considered decision processes involved in playing games like chess[3] and checkers.[4] They have worked on the assembly line balancing problem[5] and on trust investment.[6] The relevance of this research to the problem of problem finding can perhaps best be illustrated by considering the work on chess.

Research on Chess

Chess is a game with rules simple enough for almost anyone to learn and yet it is complex enough that even the largest computer cannot play it by working out the consequences of all possible moves. Chess is a game of strategy in which individual moves are not always possible to evaluate without considering future moves. Chess moves are inconvenient to describe in mathematical terms and few people can be explicit about how they play chess. For these reasons and several others, chess was an attractive medium in which to attempt to unravel human decision processes which could not be modeled mathematically.

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[2] Gelernter, H. L., "Realization of a Geometry Theorem Proving Machine," UNESCO Conference on Information Processing Proceedings (1959).

[3] Newell, A., J. C. Shaw, and H. A. Simon, "Chess-Playing Programs and the Problem of Complexity," IBM Journal of Research and Development (October, 1958), pp. 320-335.

[4] Samuel, A. L., "Some Studies in Machine Learning, Using the Game of Checkers," IBM Journal of Research and Development, Vol. 3, No. 3 (July, 1959), pp. 210-230.

[5] Tonge, F. M., A Heuristic Program for Assembly-Line Balancing. Englewood Cliffs, N. J.: Prentice-Hall, 1961.

[6] Clarkson, G. P. E., Portfolio Selection: A Simulation of Trust Investment. Englewood Cliffs: Prentice Hall, 1962.

Three aspects of the work on chess playing behavior are relevant to this discussion. First, simple explicit decision rules were discovered which play very good chess. This result has been tested by programming computers with such rules and observing the quality of play which resulted in response to the play of human experts. Second, the decision rules for chess playing were derived from observations, interviews, and the writing of chess masters. Thus it is not necessary that simple explicit decision rules be derived from mathematical or theoretical considerations. They can be abstracted from humans who have themselves never systematically considered the process of their own decision making. And, third, the decision rules by which humans play chess appear to be separable into three rather distinct classes; rules for defining alternative moves, rules for evaluating alternative moves, and rules for choosing a move from among evaluated alternatives. H. A. Simon has called these three classes of behavior respectively intelligence, design, and choice,[7/] and on the basis of his work both on chess and other decision making situations has concluded that the process of intelligence or alternative definition is the key to effective behavior.

The work on chess and other complex tasks does not directly suggest how managers go about finding and defining the problems to which they devote their time. It does suggest, however, that tasks of this same

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7/ Simon, H. A., The New Science of Management Decision. New York: Harper and Brothers, 1960, pp. 1-4.

order of complexity may be understood through careful observation of and abstraction from the behavior of human experts. It further suggests that, if useful insights into managerial problem finding can be gained, they may contribute significantly to managerial effectiveness.

## An Empirical Study of Managerial Problem Finding

Since it was possible to gain useful insights into the process by which humans play chess by observing experts, it seemed likely that insights into the process of managerial problem finding might be derived from careful observation of successful managers. Arrangements were made therefore to interview, observe, and interrogate about 50 executives in a decentralized operating division of a large technically based corporation which will be referred to as the Southern Company.

The work of the study consisted of four relatively distinct activities. First, interviews were conducted during which executives were asked to describe the problems they faced and the processes by which they had become aware of these problems. Second, observations were made of meetings during which problems were identified, discussed, and sometimes solved. Third, investigations were made of the source and disposition of several specific problems. And, fourth, a questionnaire was devised and administered to each executive who participated in the study.

As data began to accumulate from each of these activities it became clear that a major objective of the study would be to discover some level of abstraction which would preserve what seemed to be essential details of

the managerial situations being observed and at the same time provide a structure which would convert isolated anecdotes into data from which some generalizations might be drawn. This structure will be described in the following pages together with some of the observations it explains. Observations made outside this particular study will also be reported.

## A Theoretical Structure

The process of management like any number of other industrial tasks can be viewed as the sequential execution of elementary activities. In describing their own work executives find it easy to think and talk in terms of elementary activities like making out the production schedule, reading the quality control report, visiting a customer, etc. The attractive feature of this view of managerial work is that elementary tasks can be defined at almost any level of detail.

Clearly the task of preparing a production schedule is itself made up of more elementary tasks like collecting data on orders and labor availability, which are themselves made up of even more elementary activities. On the other hand, one can aggregate elements like production scheduling into larger units of analysis like managing production.

A choice of some level of abstraction cannot be avoided. For purposes of this study the level chosen was that which the managers themselves used. Thus even at the theoretical level, advantage was taken of the fact that the managers' language had evolved as a useful means for processing information about their jobs.

Elements of managerial activity will be referred to as operators. An operator transforms a set of input variables into a set of output variables according to some predetermined plan. For example, the operator "lay out a production schedule", takes machine capacities, labor productivities, product requirements, and other input variables and yields man, product, machine, and time associations covering some appropriate period of time.

Since the action of an operator produces an effect which is more or less predictable, operators are frequently named for their effect on the environment. For example, the operator "lay out production schedule" changes the production organization from one with no schedule to one with a schedule. The operator "hire qualified lathe operator" changes the size of the work force.[8/]

The word "problem" is associated with the difference between some existing situation and some desired situation. The problem of reducing material cost for example indicates a difference between the existing material cost and some desired level of material cost. The problems of hiring qualified engineers and of reducing finished goods inventories similarly define differences to be reduced.

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[8/] Because this paper is concerned primarily with problem finding, the process of operator selections and execution will not be discussed. The definitions are included here only to complete the description of the theoretical structure.

Because problems are defined by differences and operators can be executed to reduce differences, strong associations are formed between problems and operators. The "problem" of devising a production schedule can ordinarily be "solved" by applying the operator "lay out production schedule". The problem of "increasing sales volume" can sometimes be "solved" by applying the operator "revise advertising budget".

Since operator selection is triggered by the difference to be reduced, the process of problem finding is the process of defining differences. Problem solving on the other hand is the process of selecting operators which will reduce differences.

The manager defines differences by comparing what he perceives, to the output of a model which predicts the same variables. For example, a difference might be defined by comparing an idle machine to a production schedule which implies high machine utilization. In this case the production schedule is the model used to define a difference. A difference might be defined by comparing a 10% reject rate in a department to a budgeted rate of 2%. In this case the budget is the model. A difference might be defined by comparing available data to that required for a special report. The problem of understanding problem finding therefore is eventually reduced to the problem of understanding the models which managers use to define differences. The next section of this paper will discuss the models which are used by successful operating managers.

Before that discussion it should be noted that the theoretical framework proposed here has drawn on ideas discussed by Miller, Galanter, and Pribram,[9] who in turn refer to some basic work by Newell, Shaw, and Simon.[10] Figure I presents a flow chart of the process described in this section and indicates the relationship of these ideas to those which have been proposed by others.

Managerial Models for Problem Finding

Because the models to be described here were not in hand at the beginning of the study, it is not possible to supply good data on the relative frequency or other statistics on their use.

Historical Models

On the assumption that recent past experience is the best estimate of the short term future, managers maintain a wide variety of models based on the continuity of historical relationships: April sales exceed March sales by ten percent; Department X runs 5% defective product; the cost of making item Y is $10.50 per thousand; the lead time on that raw material is three weeks, etc. Because the manager's world is complex

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[9] Miller, G. A., E. Galanter, and K. H. Pribram, Plans and the Structure of Behavior, New York: Henry Holt and Company, 1960.

[10] Newell, A., J. C. Shaw, and H. A. Simon, "Report on a General Problem-Solving Program," Proceedings of the ICIP, Paris (June, 1960). (Reprinted in Computers and Automation, 8: 10-7, July, 1960, as "A General Problem-Solving Program for a Computer.")

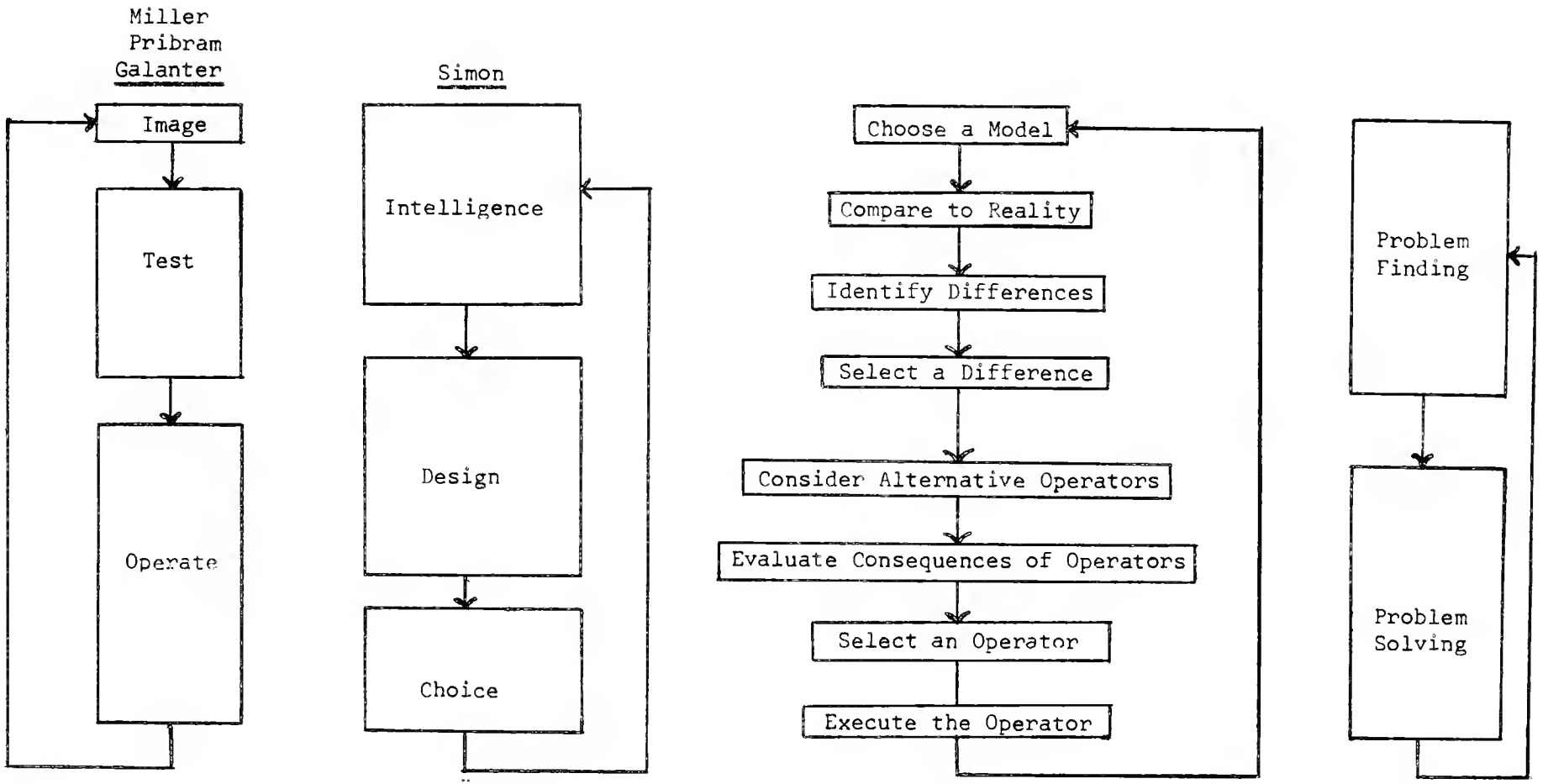


FIGURE I.

A Flow Chart of Managerial Behavior

and these models tend to be simple, discrepancies frequently arise between these models' predictions and what actually takes place. Such discrepancies are a major source of problems to which managers devote their time.

Why is our inventory account drifting out of line? Why is our reject rate so high this week? What has happened to make so many deliveries late? What can be done to reverse this trend in absenteeism? Why is our safety record suddenly so good? All of these problems and a host of others like them can keep a manager and his organization busy all day every day. All these problems are triggered by discrepancies from historical models.

For the most part these models are non-explicit. The manager "carries them in his head" or "just knows". In a number of cases, however, these models are strongly supported by routine reports. Pieces of paper on which are printed: monthly P & L statements, weekly reports of sales totals, daily reports of orders behind schedule, semi-annual inventories, and many other items of interest flow across the manager's desk in a steady stream and, except in its historical context, each one has little meaning to the manager or anyone else.[11/]

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[11/] Budgets which can also provide context for such data will be discussed in the next section.

Recognizing this fact, most management reports in the Southern Company were prepared in such a way that current figures and recent reports of the same variables appeared side by side. Trends or sharp variations in any variable could be easily noted.

The confidence placed in such analysis was clearly indicated by the fact that a large number of variables were added to routine reports following an unanticipated fluctuation in corporate profits. After several months managers could review their history of "Return on Sales", "Return on Investment", and many other variables in addition to those previously reported.

The importance of routine reports as well as the use of an historical model to identify a problem were both illustrated when the rejection rate of one department moved past an historic high and thereby attracted attention to the Quality Assurance organization. A number of other examples could be cited. 42 out of 52 managers agreed with the statement that "most improvements come from correcting unsatisfactory situations" and for the most part unsatisfactory situations were defined by departures from historically established models of performance.

Departures of performance in a favorable direction, i.e., lower than historical cost or higher than historical sales, were used to modify the historical model not to define a problem per se. Several managers reported that better-than-average performance was frequently used as evidence of what could be accomplished when reduced cost allowances or

increased profit expectations were being discussed. At the time of this study, the Southern Company was doing very well relative to its own past performance and a number of managers shared the sentiments of one who reported, "This year is going too well." They were clearly concerned about their ability to continue to meet what would become a new historical standard. Several were already working on that problem-to-be.

In another company, wage incentive standards based on running averages of past production rates have been observed to yield significant innovations. In one case a 400% increase in productivity was accomplished on an inspection operation over a period of eighteen months with no decrease in quality. By basing production requirements on past accomplishments, workers were encouraged to find their own methods and pace and they did so with completely satisfactory results.

Besides serving as triggers for corrective and innovative problem solving, historical models are used extensively in the process of devising plans for future operations. These plans are in turn converted into budget objectives and these budget objectives can sometimes serve as models which trigger managerial problem solving. Because of the complex process by which they are devised, managerial planning models will be discussed separately from the more straightforward historical ones.

## Planning Models

Managers in the Southern Company devoted substantial amounts of time to planning future operations. Detailed projections of operating variables

for the coming year and less detailed projections for the coming five years were presented annually to corporate officers by each Product Department Manager. When approved -- perhaps after some modification -- these projections were used periodically to evaluate managerial performance (as well as for other purposes).

In view of the importance attributed to planning by the Southern Company, it might be expected that planning models would constitute an important part of the problem finding process. In fact they did not. Historical models were more influential on managerial behavior than planning models. To understand why, it is necessary to examine both the function of planning models and the process by which they were devised.

Among other things, plans are organizationally defined limits of managerial independence. So long as the manager is able to perform at least as well as his plan requires, he expects, and is normally granted, the right to define his problems as he sees fit. That is to say, as long as meeting his plan does not itself constitute a problem, the manager can use other criteria for defining his problems. If, however, he is unable to perform as well as he planned, he can expect to attract the attention of higher levels of management and to receive substantial assistance in problem identification. In other words, he will lose, perhaps only temporarily, the right to manage.

One product department manager put the matter this way, "The best way to remain in charge is to be successful." Other managers strongly supported this position. Success was defined relative to the predictions of the planning model.

In view of the fact that unfavorable deviations in performance were far more undesirable to managers than favorable deviations, it is not surprising that planning models were not simple descriptions of what the managers expected would happen. On the contrary, planning models represented the minimum performance the manager could reasonably expect if several of his plans failed or were based on the minimum organizational expectations of managerial performance, whichever was higher. Planning models were in general very conservatively biased historical models.

For the most part these biases in plans were not injected surreptitiously. After approving a manager's plan, upper level managers always inquired about how he would deal with various contingencies. At this point the manager would reveal some but usually not all of his "hedges" against uncertainty. If he could report a number of conservative estimates and contingent plans to back up the plan being proposed, this was viewed as highly desirable.

In aggregating departmental plans further "adjustments" were made which led the plan to depart from expectations. In some cases these adjustments shifted expected profits from one department to another to

"make the package look OK". In other cases already conservative departmental estimates were "rounded down" to further cover contingencies. Some of these adjustments were made explicit at higher levels.

Even with all its conservative biases, the Division's plan still exceeded the Corporation's minimum profit and volume expectations. It is not surprising, therefore, that the planning model was a far less important source of management problems than historical models. Extrapolations of past performance simply implied much higher levels of performance than the planning model called for. Only in those cases (not observed) where the corporate expectations required improvements over historical results would one expect planning models to be important in the process of problem finding.

Other Peoples' Models

Some models which define problems for the manager are maintained by other people. A customer whose model of product quality is violated by the product he receives may notify the manager of the producing organization of this fact and thereby define a problem for him. A higher level manager may lack information to complete an analysis and this discrepancy can define a problem for a lower level manager. An employee may need a decision on vacation policy and his request will define a problem for his supervisor. A basic function of an organization structure is to channel problems which are identified by its various

members to individuals especially qualified to solve them. Managers as well as other members of the organization do not always work on problems defined by their own models.

In the Southern Company invitations to attend meetings, requests to prepare reports, and requests for projects of various kinds whether made by superiors, subordinates, or peers were rarely questioned by managers as appropriate ways to spend their time. While it was easy to get sometimes vehement testimony as to the uselessness of many of these activities, the behavior of managers clearly indicated the strong influence of other people's models.

One reason for the influence of these models may be the cost to the manager of doubting them. Any attempt to validate each request made on him could easily imply a heavier workload on the manager than the simple execution of the work requested. In addition, by providing "good service" the manager builds (or at least many believe they build) a store of goodwill among other managers toward his own requests.

Confidence in other peoples' models is sufficient in many cases to provide the manager with an insurmountable work load. A survey of highly successful middle managers who were participating in an executive program at M.I.T. indicated that such models provided the vast bulk of their work load. In those rare cases where these models left some free time, several of these managers indicated they "walked around the shop" or "talked with people" -- indicating perhaps a reluctance on their part to undertake problems which were not defined by someone else.

During the course of the company study, several clear examples of the influence of these models were observed. In a series of interviews, managers were asked to specify the problems currently faced by them and their organizations. Most of them mentioned from five to eight problems. Later in the same interview each manager was asked to describe in broad terms his own activities for the previous week. In reviewing the data from these interviews as they were collected, it was noted that no manager had reported any activity which could be directly associated with the problems he had described.

In order to be sure that this result was not due to some semantic problem, this point was discussed with several managers -- in some cases during the first interview with them and in some cases as a follow-up question.

One manager found the point both accurate and amusing. He smiled as he replied, "That's right. I don't have time to work on my problems -- I'm too busy." Another manager took a different tack in agreeing with the general conclusion. He replied rather confidentially, "I don't really make decisions. I just work here." In further discussion with a number of managers the power of other peoples' models was repeatedly indicated. The influence of these models was also noted in the case of a rather involved project which was observed in some detail.

The Plant Engineering Department (using a quite different model)[12/] decided to look at the desirability of revising the management of the Company's 21 fork trucks. Besides scheduling and other operating questions which were investigated by people within the Engineering Department, studies of the contract under which the trucks were leased and an economic evaluation of leasing versus buying trucks were also felt to be required.

The Manager of Plant Engineering called representatives of the Comptroller's organization and the Legal Department to a meeting where the project was discussed in some detail. This discussion clearly indicated that the project was risky both from the point of view of economic payoff and political considerations. The representatives accepted their tasks, however, and in due course their studies were completed. In neither case did the studies take much time, but the assumption that it was the job of the Accounting Department and the Legal Department to serve the Plant Engineering Department was clear. A problem found by someone in the organization carries with it substantial influence over the problems on which other parts of the organization will work.

Even clearer evidence of the power of other peoples' models was the time devoted by all the managers in the Southern Company to the preparation of reports "required" by higher management. These reports ranged in their

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[12/] Discussed on pages 24-26.

demands on managerial time from a few minutes in the case of a request for routine information to several man months of work on the preparation of a plan for the coming year's operations. In reply to the question "If you were responsible for the whole company's operations would you require more, the same or less planning?" 52 managers responded as follows:

| | | |
|---|---|---|
| More | - | 4 |
| Same | - | 32 |
| Less | - | 16 |

For many managers the expectations of the organization were consistent with their own ideas of the time required for effective planning. For a number of others, however, the influence of other people was clear.

It is difficult in discussing these models as a source of problems to avoid a negative connotation due to the widely held ethic which values individual problem definition. Two points are worth emphasizing therefore. First, the study was conducted to find out how managers do define their problems -- not how they should do so -- although that, of course, may be a long term objective of this work. Second, both the organization and the individuals described here would, by almost any standards, be judged to be highly successful and this fact should be included in any attempt to evaluate their behavior.

Because historical, planning, and other peoples' models require almost no generalization to make them relevant to particular events of interest to the manager, and because these three types of models can easily generate

more problems than the manager can reasonably hope to deal with, it is not surprising, perhaps, that models requiring somewhat more generalization are less important elements of the process of problem finding. It is true, however, that on occasion managers draw on experiences other than their own to define problems for themselves and their organizations.

Extra-organizational Models

Trade journals which report new practices and their effects in other organizations can sometimes define useful areas for managerial analysis. Customers frequently serve the same function by reporting the accomplishments of competitors in the area of price, service, and/or product quality. General Motors is known for its practice of ranking the performance measures of a number of plants producing the same or similar products and making this information available to the managers of these facilities. The implication is strong in these comparisons that problems exist in plants where performance is poor relative to other plants.

In using all such extra-organizational models to define intra-organizational problems, the manager must resolve the difficult question of model validity. "Is the fact that our West Coast plant has lower maintenance costs relevant to our operations? After all, they have newer equipment." "Is the fact that our competitor is lowering is price relevant to our pricing policy? After all, our quality is better." Etc. There are enough attributes in any industrial situation to make it unlikely indeed that any extra-organizational model will fit the manager's situation perfectly. Judgments on the question of model validity must frequently be made by operating managers.

In the Southern Company one clear case was observed where two extra-organizational models were employed in an attempt to define a problem.

A member of the Plant Engineering Department attended a meeting of an engineering society at which a technique called "Work sampling" was discussed in the context of several successful applications in other plants. This model of a current engineering practice, which had not been employed by his department, led this man to consider the problem of finding an application for work sampling in the Southern Company. Clearly if this technique could be successfully applied, it would reduce the difference between his department and his extra-organizational model.

A few days later this engineer noticed an idle, unattended fork truck in one of the manufacturing shops and he immediately thought that an analysis of fork truck operations might be the application he was looking for. He discussed this idea with his supervisors and they agreed that the project should be undertaken.

In a sense, a study of fork trucks was a strange problem for Plant Engineering personnel to undertake because fork trucks were not their responsibility. Each product department paid rental charges on the trucks it used to a leasing company which provided maintenance service as a part of their contract. The product departments were also responsible for the operation of the trucks. Production workers operated the trucks on an ad hoc basis as a part of their regular duties. No full-time drivers were

assigned. Because of the lack of direct responsibility for fork trucks, Plant Engineering was aware from the beginning of the project that its primary task would be to convince the product departments that their fork trucks indeed constituted a problem.

To provide the department managers with evidence on this point, in addition to the internal work sampling study, a survey of fork truck operations was made in six nearby plants engaged in similar manufacturing operations. The explicit purpose of the survey was to define a basis (an extra-organizational model) on which internal fork truck operations could be evaluated.

The work sampling study indicated the following activity levels for the set of 21 trucks rented by the product departments:

| | | |
|---|---|---|
| 1. | Travel Loaded | 22.2% |
| 2. | Travel Unloaded | 11.9% |
| 3. | Travel Empty | 10.4% |
| 4. | Idle Empty | 43.1% |
| 5. | Idle with Driver | 2.5% |
| 6. | Loaded no Driver | 9.9% |

Combining categories 1, 2, and 3 as "usage" categories, a 44.5% "utilization factor" resulted.

The six company survey yielded in part the following results:

1. The number of trucks operated by the surveyed companies ranged from 6 to 50 with an average of 21. (Same as Southern Company),

2. Utilizations ranged from 50% to 71% with an average of 63% (18.5% higher than Southern Company),

3. Responsibility for trucks was centralized in all six companies (Contrary to Southern Company),

4. Trucks were controlled through dispatching or scheduling on five of the six companies (some companies used radio control) (Contrary to Southern Company),

5. All companies owned rather than leased their trucks (Contrary to Southern Company),

6. All reporting companies performed their own maintenance of their trucks (Contrary to Southern Company),

7. Three companies licensed their drivers, and assigned them full time to driving (Contrary to Southern Company).

The fact that the surveyed companies on the average operated the same number of trucks as the Southern Company was clearly cited as evidence supporting the validity of this extra-organizational model.

A comparison of Company practice to these survey results led Plant Engineering to draw the following conclusions which are quoted from their report:

1. Utilization of trucks is 20% lower than average.

2. Dispatching or scheduling of trucks from central group should be considered.

3. Radio control of some units shall be investigated.

4. Central responsibility for trucks should be established.

5. Trucks should be purchased not leased.

6. Operator training and licensing should be instituted.

In the opinion of Plant Engineering, therefore, the survey and work sampling study had established the existence of not one but a number of related problems.

Because the six company survey and the work sampling study had defined the problem in aggregate terms, the analysis and recommendations proceeded at this level. The Plant Engineering Department decided to make their recommendation on the basis of an overall utilization of 60% (the average utilization found in the six company survey) which implied a reduction of five trucks. They then looked at their work sampling data and re-allocated trucks among departments to bring individual truck utilization figures as close to 60% as possible. The recommended re-allocation in fact implied a saving of five trucks. The recommendation went on to suggest that Product Departments "compensate [for this reduction in trucks] by establishing sharing arrangements between departments."

The recommendation also proposed "permanent [full time] licensed drivers". "The drivers will report administratively to the Vehicles and Grounds Foreman [Plant Engineering]. Drivers will be assigned from presently available men doing driving. Men not selected as drivers will work at jobs vacated by permanent drivers in addition to their other duties. No

men will be dropped." As a result of a study which had indicated that leasing was preferable to buying the fork trucks, no change in ownership or maintenance was proposed. The annual savings anticipated from the recommended changes amounted to $7,250/year.

It is interesting to note that the recommendations themselves constituted problems for the Product Department Managers. The task of "establishing sharing arrangements among departments" had not been resolved by the study and remained a thorny problem. The task of transferring qualified production workers to full-time truck driving duties [and the Plant Engineering Department] involved not only complex problems of morale and labor relations but also involved economic trade-offs not evaluated by the study. The task of redefining departmental work procedures to relate to centrally controlled truck services was similarly unresolved. In return for these problems the seven product department managers could expect to share in an annual saving of $7,250.

Their response to the recommendation was less than enthusiastic. They agreed, after some bargaining, to return one truck to the leasing company but were not willing to pursue the matter any further than this.

Despite this rather negative conclusion it is interesting to note that most managers considered the fork truck study a success. The validity of using the extra-organizational model derived from the survey as a means to define the problem was never questioned and an evaluation of the existing policy on this basis was considered well-justified.

It was clear, however, that extra-organizational models did not carry with them the same direct implications as models based on intra-organizational experience. The observation that the Company's central office used time clocks to control tardiness of clerical personnel was not viewed as relevant to discussion of this same problem at the Divisional level. The comment, "We have never done that.", was sufficient to discredit this evidence.

A more complicated use of extra-organizational models occurred in the case of several managers who had had personal experience in other organizations. In several situations they used this experience to define intra-organizational problems by emphasizing the personal element of this experience as evidence of its validity and by de-emphasizing (or not mentioning) where this experience was gained.

Extra-organizational models have a natural disadvantage as sources of problems because of the question of model validity which can always be raised against them. When extra-organizational experience agrees with local experience (historical model) it is seen as valid but since it agrees with the local experience it defines no problem. When extra-organizational experience disagrees with local experience and might therefore define a problem, the discrepancy itself raises the question of model validity. This attribute of extra-organizational models may serve to explain the fact that they were a relatively weak source of management problems in the Southern Company. 47 out of 52 managers agreed with the statement "Most of our new ideas are generated within the Company".

In the case of new organizations, of course, historical models are not available and extra-organizational models become more influential. One such situation was observed in the Southern Company.

A promising new product was moving from the latter stages of development into the early stages of production and sales. A new product department was formed on an informal basis and the standard procedures of accounting data collection and reporting were instituted. No one expected the new department to be profitable immediately but after some months an executive at the product group level used a model not based on the history of the new department but one based on the performance of other departments to define a problem. He described the process this way:

> "The numbers [on the monthly reports] were horrifying. I asked for a report and I got fuzzy answers that I didn't believe so I said 'Fellows, I'm taking over the right to ask questions.'
>
> "In asking questions I found I could pick holes in their analysis of the situation. Everything was loose."
>
> "I analyzed their orders and found with their overhead they couldn't make money."
>
> "The department was reorganized."

In new organizations extra-organizational models can be quite powerful sources of management problems.

Some Normative Questions

The principal objective of this study was to find a relatively simple theoretical structure to explain the process of problem finding used by the managers at the Southern Company, and the set of four models just described represents that structure. These models, which range from ones maintained by other members of the organization, through simple historical and planning models, to those which apply the experience of other organizations to local situations, have been tested against the rather massive sample of data collected at the Southern Company and have been found sufficient to explain all these observations. That is to say, it is possible to trace all the observed behavior back to differences defined by one of these four classes of models. To this extent the study was successful.

But observations like these, even after abstraction into a theoretical structure, are only observations. They do not suggest the consequences of using other kinds of models or using these same models with different frequencies. They do not suggest how managers might behave more effectively than they do.

Isolated observations cannot define differences. Observations must be compared to a model before normative questions can be answered.

One way to generate such comparisons would be to conduct comparative studies within and among a number of organizations. As a result of this work one could answer questions like: "Are these same models used by unsuccessful managers? If so, how can the difference in performance be

explained? If not, what models are used? Do managers in other organizations use these models with different frequencies or under different circumstances? Are there systematic differences in the use of these models at different levels of the organization?" All such questions could be answered by careful study of several organizations or several levels of the same organization and these extra-organizational models might serve to suggest management improvements. Until such studies are completed, however, the only models which can be used to evaluate the behavior observed in the Southern Company are some which were not used there.

## Scientific Models

When compared to models used in the physical and social sciences for quite similar purposes the models used by the managers in the Southern Company (and elsewhere) are almost startling in their naivete. In the same company electrical engineers explicitly used quite complex theoretical models to help them define problems associated with the design of a relatively simple electronic control system. Mechanical engineers similarly employed a variety of quite general theories in the design of new high speed production equipment. In neither of these cases did the engineers base their predictions on their own experience except in a very general sense. They quite confidently applied theories derived from the observations of others and the equipment which resulted from their work required relatively little redesign after construction.

Managers on the other hand based their expectations on relatively small samples of their own experience. Their rather simple theories, as has already been noted, yielded rather poor predictions and managers therefore spent a substantial amount of time problem solving either on their own problems or on those defined by others.

The behavior of scientists (an extra-organizational model) suggests that there is an alternative to this rather frantic approach to a complex world. When discrepancies arise between a model and the environment, one can undertake to improve the model rather than to change the environment. In fact, a scientist might even go so far as to suggest that, until one has a fairly reliable model of the environment, it is not only foolish but perhaps even dangerous to take action when its effect cannot be predicted.

If carried to an extreme, of course, the scientist's tendency to search for better models of the world as it is, would leave no time for taking action to change it, and it seems unlikely that this allocation of time and talent would be an appropriate one for the operating manager. In the Southern Company, it must be remembered, those managers who based their actions on very simple models which took very little of their time to construct were judged to be quite successful by their organization.

On the other hand, the increasing use by managers of more sophisticated modeling techniques like those mentioned earlier in this paper may suggest that the balance between model building and action taking is shifting. A number of companies now base changes in distribution systems, production

and inventory control systems, quality control systems, advertising allocation systems, etc. on the predictions of relatively complex models which are based on substantial bodies of theory and empirical evidence.

To the extent that these models fail to describe events which take place they, just like the simpler models they replace, can serve to define problems. To the extent that these more complete models take into account events which the manager cannot, or prefers not to, control, these models can serve to protect the manager from problems on which he might otherwise waste his energy.

While it may be true that these more explicit scientific models will gradually replace simple intuitive models, several reasons suggest that the change will take some time. First, as has been frequently noted, many operating managers today find the language of the new techniques foreign despite increasing attempts to change this situation through training. Second, the new techniques often involve even more generalization than extra-organizational models and honest questions of model validity will tend to delay their widespread use. And third, the process of problem finding currently used will perpetuate itself simply by keeping managers so busy that they will find little time to learn about and to try these new methods of problem finding.

More important than any of these reasons, however, may be one which, curiously, has been created by the advocates of management science.

In most, if not all, of the literature describing them, model building techniques are described as means for solving management problems. In their now classical book on operations research, Churchman, Ackoff and Arnoff, for example, suggest model building as a step which should follow "formulating the problem".[13/] The process by which the problem should be formulated, however, is left totally unspecified -- and this is where managers as well as students of management frequently report their greatest difficulty. They can see the process by which these techniques can solve problems but they cannot see how to define the problems.

The theory which has been proposed here suggests that problem definition cannot precede model construction. It is impossible to know, for example, that a cost is too high unless one has some basis (a model) which suggests it might be lower. This basis might be one's own experience, the experience of a competitor, or the output of a scientific model. Similarly, one cannot be sure that his distribution costs will be reduced by linear programming until a model is constructed and solved which suggests that rescheduling will lower costs. The imperfections of an inventory system are revealed only by comparing it to some theoretical model -- therefore, they cannot be defined until after the model has been built. The logical inconsistency which suggests that problems must be

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13/ Churchman, C. W., R. L. Ackoff, and E. L. Arnoff, Introduction to Operations Research. New York: John Wiley and Sons, Inc., 1957, pp. 12-13.

clearly defined in order to justify model construction is very likely an important reason that scientific models will only slowly be recognized by operating managers as important aids in the definition of their problems.

Despite their current disadvantages, the so-called new techniques of model building are, as has already been noted, making significant contributions to management effectiveness. They represent, therefore, not only a means for evaluating current managerial behavior but also are becoming a new class of models which can be used by managers to define their problems.

## The Problem of Model Selection

The study of managers in the Southern Company indicates that concepts like image, and intelligence which have been proposed to explain the process of problem finding can be made somewhat more operational. A rather small set of model classes have been defined which constitute sufficient stimuli to trigger a fairly large sample of managerial behavior. This is not to say that further observations may not indicate the need for additional model classes or that further work is not required to make the process of managerial model building even more operational and testable. The study of the Southern Company represents perhaps only an encouraging start at understanding an important and little understood area of management.

Even with these initial insights, however, it is possible to see where major theoretical gaps still exist. Chief among these is the problem of model selection.

As has already been noted, the requests of other people are sufficient to define a full time job for many managers. The problem of investigating and taking corrective action on discrepancies from historical trends can keep any manager busy all the time. The construction of extra-organizational and/or scientific models and the actions which they trigger are similarly time-consuming. Even after the manager has constructed the models he will use to define his problems he must somehow select from among the differences which are simultaneously defined by these models. Personal requests, historical discrepancies, extra-organizational ideas, and the stimuli of scientific models do not in general define differences one at a time. The choice of the discrepancy to attend to next may be as important a process as the construction of the models which define them. It seems clear, however, that we must understand the process by which differences are defined before we can worry seriously about understanding the process of selecting from among them. The study in the Southern Company, therefore, largely ignored the priority problem and concentrated on difference definitions only.

It is impossible, however, to observe managers at work without getting some rough ideas about how they deal with the priority problem. Telephone calls for example are very high priority stimuli. A ringing telephone will interrupt work of virtually every kind. This priority rule is complicated sometimes by an intervening secretary but many managers pride themselves on always answering their own phone.

One manager reported that he always worked on problems which would "get worse" before he worked on static problems. Thus, he dealt with a problem involving a conflict between a foreman and a troublesome employee before pressing forward on a cost reduction program.

Perhaps the most explicit priorities in the Southern Company were established by means of deadlines. Most problems defined by other members of the organization carried with them a time at which, or by which, the request should be satisfied. Certain reports were due monthly, a fixed number of working days after the end of the preceding month. Meetings were scheduled at stated times. Annual plans were required on a specified date. While a number of such requests might face a manager simultaneously, they almost never would have the same deadline and by this means the manager could decide which to do when. The fact that most problems triggered by other people's models carried deadlines may explain why these problems seemed to be given so much attention. When asked to indicate "Which problems do you usually get to first, time deadline, big payoff or personal interest?", 43 out of 52 managers indicated time deadline.

From a theoretical point of view one could view the flow of problems through an organization as analogous to the flow of jobs through a job shop and perhaps apply some of the theories which have been developed there to understand and perhaps prescribe the process of priority assignment. Managers, for example, must trade off relative lateness of their tasks

with the duration of the tasks just as a foreman loading machines in a machine shop. Once the problem of problem definition is well understood it would appear that some theory is already available to structure the process assigning problem priorities.

## Summary and Conclusions

Applying the same reasoning which had proved useful in understanding the process by which chess is played, a study which involved interviews and observations of managers in a successful industrial organization was conducted in order to gain some insight into the process by which managers find and define their problems. A theoretical structure was devised which organized managerial problems by means of the models used to define them.

Four classes of models proved sufficient to explain the sample of data collected during the study. These models -- largely inexplicit and intuitive in nature -- were compared to more formal models used by engineers and scientists. No value judgements could be made on the basis of this comparison but the recent trend in model sophistication may indicate that managers will spend more time building models to guide their attention and proportionately less in problem solving.

The array of models used by and available to managers suggests that an understanding of the process by which problems are defined will not constitute a complete theory of problem finding. A process which assigns priorities to a set of simultaneously defined problems remains to be specified.